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Effect of Temperature on Memory

Promila Batra and **Reema Garg**
M.D.University, Rohtak

A multi-group experiment was conducted on a sample of 75 male albino rats weighing 155±5 gms, belonging to the age of about three months, in order to investigate the effect of temperature on memory. The five levels of temperatures taken were 7^0C, 15^0C, 25^0C, 32^0C, 38^0C. A multi-trial active-avoidance task was used. Retention was tested after 24 hours of the training. Results indicated that higher degrees of temperature (32^0C, and 38^0C) led to slower acquisition and poor retention of the task as compared to the moderate level of temperature (25^0C). But lower degrees (7^0C, 15^0C) of temperature did not have any significant negative effect on acquisition and retention. The results have been interpreted in terms of level of arousal and attention decrement caused by varied levels of temperature.

Heat is a form of energy measurable in terms of temperature by thermometers, whereas ambient temperature describes the surrounding or atmospheric temperature conditions. In a natural environment, human experiences a range from arctic cold to debilitating tropical heat.

The temperature of the air influences the body temperature. The body tends to maintain a constant temperature by reflex responses which lower or raise its temperature as per the need. In cool air excessive heat must be resupplied rapidly to maintain a constant body temperature. In very warm air (warmer than the skin), on the other hand, the body absorbs heat from the surrounding. The body temperature would rise by about 2^0C per hour if not offset by evaporating cooling from the lungs and skin, and by radiation. The atmospheric temperature is a factor which influences the way the body must function to maintain a constant temperature of 37^0C, that is necessary for survival. So the change in temperature leads to stress in the body that has been called as “Thermal Stressor.”

An individual usually becomes aware of the temperature of environment and has a distinct sensation of heat or cold. Such awareness occurs when there is an imbalance of the thermal interchange between ourselves and the environment. Such an imbalance can affect the health, performance and the comfort as well. There are evidences suggesting that mental performance is negatively affected by thermal stressors (Bursill, 1958; Poulton, 1980). The earlier studies on the effects of temperatures also indicate a narrowing of attention due to very high or low temperatures (Hancock, 1992; Rajmjou & Kjellberg, 1992). Learning and memory are also attention based mental functions. Therefore, it seems plausible to hypothesize that the thermal stress may lead to poor memory. Keeping this in mind, the present investigation was designed to study the effect of ambient temperature on

memory. The following hypotheses were formulated:

Hypotheses

i. Higher degrees of temperature would lead towards slower acquisition and poor retention as compared to moderate level of temperature.

ii. Lower degrees of temperature would lead towards slower acquisition and poor retention as compared to the moderate level of temperature level.

Method

Sample

A sample of about three months old, 75 male albino rats, weighing 155±5 gms was selected randomly from the rat population of the Animal House of the Department of Psychology of Maharshi Dayanand University, Rohtak. The rats were further assigned randomly to five different groups (15 animals/ group). Identification marks were assigned to each animal and they were housed in wire cages on free feeding schedule.

Design

A multi group experiment was conducted to study the effect of various levels of ambient temperatures on memory. Five levels of temperature were 7^0C, 15^0C, 25^0C, 32^0C, and 38^0C.

Material Used

The active-passive avoidance apparatus: The apparatus consisted of a trough shaped alley way. There was a gap of 1 cm at the base, so that the urine and faeces drop out automatically. It was divided by a one inch thick wooden wall into two compartment which were 60 and 30 cms long. There was a circular hole fitted with a sliding door in the partition wall through which the rat could enter the other compartment. The inner surface of the apparatus was covered with aluminium sheet, which could be connected to the shock generator. Both compartments had transparent glass covers, so that the activity of the animal could be constantly observed.

Electric shock generator

An electric shock generator that could pass the electric shock current of the intensity ranging from 0 to 4mA and duration was ranging from 0.1 to 10 seconds was used. It was connected with the active-passive avoidance apparatus through a servo-controlled voltage stabilizer.

White noise

When sounds of different frequencies are mixed up in such a way that they have the same amount of energy output, the resultant hiss like sound is called white noise. A taped white noise recorded from an electronic white noise generator was played while running / testing the animals because any kind of noise due to movements in corridors, outside / inside of the laboratory could profoundly influence and change the behaviour of the animal.

Humidity chamber

To expose the animals to different levels of temperatures a Swastika humidity chamber was used. It consists of both heating and cooling devices which could be switched on / off according to temperature required in the chamber. There are two thermometers fitted in the holes at the top surface of the apparatus. Upper scale has been provided with an indicator which can be adjusted at any point depending upon temperature level required in the chamber. Lower scale records the actual temperature level inside the chamber.

Procedure

A multi-group design was run in this investigation. There were 5 groups and each group consisted of 15 subjects. Five levels of temperature were selected for the present investigations i.e. were 7^0C, 15^0C, 25^0C, 32^0C, 38^0C.

First of all a rapport was established with randomly selected rats by handling them for at least half an hour, one day before starting the actual experiment. An orientation trial for 10 minutes was given to each rat in order to familiarize the animal with the active-passive avoidance apparatus. Next day, the training was given. Before training, each rat was exposed to a predetermined level of ambient temperature in the temperature chamber. However, the duration of exposure was varied for low and high temperature groups. It has been observed that the change (fall) in body temperature brought about by the cool condition is comparatively slow (Grayson & Mendal, 1956) than the change (elevation) brought by hot conditions (Okuno et al, 1965). So, the exposure duration for cool condition () was 60 minutes and for hot conditions (), it was 30 minutes. These directions were selected on the basis of the pilot work conducted by another in investigator in department (Sheenu, 1997).

During training all the lights of room were switched off except an adjustable lamp on the larger chamber of the alley. The small chamber was kept dark. Large chamber was connected with a shock generator which was adjusted to deliver a continuous shock of 0.97 mA.

First of all a rat was placed in the large illuminated chamber facing towards the sliding door at the end of compartment. Simultaneously a stop watch was switched on. After ten seconds of the beginning of trial, the shock generator was switched on to pass on the continuous shock of 0.75 mA. When the rat entered the small member, the stopwatch was put off to record the latency period and the door was also closed. In small chamber rat was retained for 30 seconds. If the rat failed to enter the small chamber within 40 seconds of the beginning of the trial, the shock was turned off and the rat was placed in small compartment for 30 seconds. In such cases a latency of 40+ was recorded. This procedure was repeated till the animal reached the criterion of three consecutive successful avoidance trials. The training trials were subject to a maximum of twenty and a minimum of eight. Before every trial the apparatus was cleaned with 50% spirit solution and it was dried with an air blower to remove the odour traces left by the earlier run animals and the moisture which could vary the amount of electric current actually passing through the body of the animal. The white noise was also played on whenever the animal was put into the apparatus throughout the experiment, in order to mask the effect of external noises.

After 24 hours of training the retention was tested. The procedure for the retention was similar to that of training trials except that no shock was given. If the rat entered the safer chamber, the time between placing and entering was recorded as the retention latency. If the rat did not enter the safer chamber within 40 seconds from the beginning of the trial, it was placed into small chamber for 30 seconds and then the trial was terminated. This retention test consisted of 6 trials taken in the same way.

Results and Discussion

The first hypothesis of this investigation was that the higher degrees of temperature would lead towards slower acquisition and poor retention as compared to moderate level of temperature. The obtained mean acquisition trials under five different ambient temperatures and the significance of differences amongst these groups tested upon Duncan's Range Test: (DRT) have been presented in Table 1. These results are also graphically depicted in Fig. 1.

Table1 Differences amongst mean acquisition trials taken by 5 groups under different ambient temperature levels.

Groups	3	2	1	4	5
Ambient temperature	25^0C	15^0C	7^0C	32^0C	38^0C
Mean acquisition trials	9.0	9.3	10.1	11.3	11.6

It is clear from Table 1 that the mean acquisition trials of 25^{0}C groups are lowest and significantly different from the trials taken by the subjects in high temperatures i.e., 32^{0}C and 38^{0}C. it means that the group exposed to moderate temperature acquired the task faster than the groups exposed to high temperatures. In other words the high temperatures had a negative effect on the acquisition speed. So the prediction about acquisition in hypothesis one has proved that higher degree of temperature would lead towards slower acquisition.

The second prediction in the first hypothesis was that higher degrees of temperature would lead towards poor retention. For testing this a retention test was given to the subjects after 24 hours of training. The obtained mean retention under different ambient temperatures and significance of these differences tested upon DRT have been presented in Table 2.

Table 2: Differences amongst mean retention latencies of five groups exposed to different ambient temperature levels.

Groups	3	2	1	4	5
Ambient temperature	25^{0}C	15^{0}C	7^{0}C	32^{0}C	38^{0}C
Mean acquisition trials	7.8	14.8	15.9	18.7	26.4

It is clear from table 2 that the mean retention latency of moderate temperature group (25^{0}C) is lowest and significantly lower than both the high temperature groups (32^{0}C and 38^{0}C) retention latencies since a higher latency in the active avoidance task is indicative of forgetting, the second prediction of first hypothesis has also proved. In fact the retention latency in 25^{0}C is less than 10 sec indicating a complete retention of the task amongst the subjects of this group.

A temporal conditioning paradigm was used in this investigation. Limit for the safe period was 10 seconds. Therefore, a retention latency of less than 10 seconds is indicative of complete retention in the 25^{0}C group subjects. On the other hand higher retention latencies in the high temperature groups not only show comparatively poor retention. Rather these are also indicative of complete forgetting. Thus the high temperature levels taken in this investigation led towards both slowing down of acquisition and forgetting of the training after 24 hours of complete learning.

The second hypothesis predicted that the lower degrees of temperature would lead towards slower acquisition and poor retention as compare to moderate temperature level.

It is clear from table 1 that the trials in low temperature groups were not significantly different from 25^{0}C group. The mean acquisition trials in the lowest degrees i.e. 7^{0}C did not differ significantly from 25^{0}C indicating no any negative effect of cool ambient condition upon acquisition. But it is interesting to note that mean number of acquisition trials in 7^{0}C did not differ from the higher temperatures, which showed that both the lowest and their high temperatures had similar and equally deteriorating effect. Thus, although the prediction has not been proved, yet it is difficult to conclude and generalize that the lower degrees of temperatures would not lead towards slower acquisition. Rather a deeper probe by using a higher number of subjects and using different species is suggested.

The other part of this hypothesis predicted that the lower degrees of the temperatures would lead towards poor retention. It is evident from table 2 that, mean latencies of 25^{0}C group are lowest but these are not significantly different from low temperature groups (7^{0}C and 15^{0}C). Although obtained retention latencies were more than

10 seconds but these are not significantly different from latency score of moderate temperature group. It reveals that low ambient temperatures had a less negative effect on retention than the high ambient temperatures. As already mentioned a temporal conditioning task was used. The retention latencies (except in the case of the moderate level of temperature i.e. 7^0C) are higher than 10 seconds which is indicative of forgetting in low and high ambient temperature groups. Therefore, it is suggested that more experimentation, using some other variable as conditioned stimulus should be conducted to explore the effects of lower temperatures on retention latencies. Thus, the second hypothesis has not been proved as in this investigation, the lower degrees of temperature neither led towards slower acquisition not towards a poor retention as compared to moderate level of temperature. However, it is interesting to note that even in the earlier existing literature, the effect of cold on mental performance has been shown to have contradictory results (Bowen, 1968; Gamberale et al., 1989). In another investigation to confirm these results (Sheenu & Batra, 1997) the results obtained were slightly different. Here, higher degrees of temperature led to both slower acquisition and poor retention. But the lower temperatures led tp slow acquisition having no effect on retention.

Graphic presentation of these results (figure 1 & 2) shows 'U' shape curve plotted against mean acquisition trials / retention latencies and ambient temperature. In other words, an inverted U shape relationship was obtained between acquisition speed / retention and the ambient temperature.

To sum up these results, high temperatures have proved to be the worst for both acquisitions of active avoidance task as well as its retention but low temperatures had no any significant negative effect on both the acquisition and retention, 25^0C temperature condition has proved to be the optimal condition for learning and memory situation in rats. Without calling on reverse heat loss or gain functions, at this temperature the rats can maintain their body temperature at optimal level (Prosser & Brow, 1961).

One more possible reason for low temperatures to be less deleterious might be that the rats have fur on their body. Although long enough of exposure was given, yet the fur might have served as insulation in the cold conditions and thereby help resist the cooling of the body. In hot conditions, the thermal conductivity of fur is very low (Scholander et al., 1950). Thus fur also reduces the heat loss by convection and may add heat dissipation to rat's body. In this way fur may impose a disadvantage in hot conditions. Secondly, rats have no sweat glands and they are poor regulators of heat (Frankel, 1959). So there is every possibility that the effect of temperature upon human beings may be different from these mammals.

The negative effect of high temperatures on acquisition and retention can also be explained in terms of arousal hypothesis. The hypothesis explains that the effect of an increase in body temperature under hot conditions is to produce an increase in the general level of arousal of the subjects (Poulton, 1980). A number of studies have reported decrements in mental tasks demanding intense attention and concentration by heat exposure (Bursill, 1958; Fine and Korbick, 1978). Thus it is possible that the arousal level of subject might have increased, causing insufficient attention to the learning task, and thus the acquisition and retention suffered.

Although there are no much evidence of this kind, yet there is one study that the E came across while collecting the literature indicating similar results. In this study with

humans, Allen and Fischer (1978) found that the retention of paired learning was decreased under temperature of 82^0F and 92^0F.

These results of suggestive of the fact that temperature as an environmental variable does play an important role in learning and memory. Although the external and natural weather conditions cannot be compelled, at least an attempt should be made to carefully design our offices, work places, and educational institutions. The findings bear more utility particularly for the working conditions in the industry where the machines are also a source of heat generation adding to the existing outside temperature.

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Promila Batra, PhD Professor, Department of Psychology, M.D.University, Rohtak-124 001, Haryana

Reema Garg, M.D. University, Rohtak-124 001, Haryana.